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MEASUREMENTS OF UV RADIANCE(U) AIR FORCE GEOPHYSICS LAB
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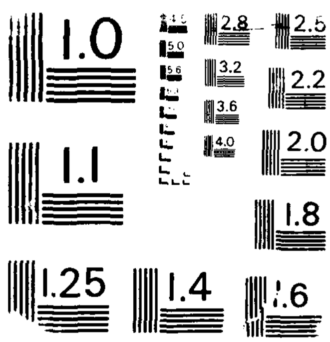
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Comparison of the LOWTRAN 7 code and S3-4 satellite measurements of UV radiance

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ABSTRACT

Atmospheric radiance measurements and model calculations in the 200-290 nm wavelength region are found to be in good agreement. The calculations are made using the recently released LOWTRAN 7 transmission and radiance code. The measurements were made in 1978 from the S3-4 satellite. The model is in excellent agreement in regard to radiance level and to spectral variability in this region for the daytime, mid-latitude measurements. Under twilight conditions, the lack of airglow and fluorescence emission sources in the code lead to differences. Additions to the model to provide better agreement are under consideration, but at the present time, the code can be used for a wide range of atmospheric problems.

1. INTRODUCTION

The development of applications for the ultraviolet has been hampered by the lack of sufficient attention to transmission and radiance models. We report here an initial, partial answer to this need using the LOWTRAN 7 transmission and radiance model. This code was originally developed for the infrared, has been recently revised with a significant addition of coverage to a short wavelength limit of 200 nm. An initial report on LOWTRAN 7 is available.[1]

We will demonstrate that the model radiance values agree well with previously existing satellite radiance data for situations where solar scatter dominates the earth's atmospheric radiance as seen from space.

2. LOWTRAN 7 IN THE ULTRAVIOLET

Among other improvements to the LOWTRAN transmittance and radiance code, the wavelength region covered has been extended to 200 nm. In order to do this, the atmospheric absorption by ozone has to taken into account using appropriate pressure and temperature dependence. In addition, the absorption of molecular oxygen in the Herzberg continuum and in the 0-0 and 1-0 bands of the Schumann-Runge system have to be included. Finally, the daytime radiance is dominated by Rayleigh scattering, and so the cross-sections for scattering have to be included.

Since the radiance is so tied to the solar flux, due to the Rayleigh scattering, it is important to use detailed and accurate solar flux values. For this purpose, solar irradiance values derived primarily from Spacelab measurements at *0.15 nm resolution* have been used. These detailed measurements allow the structure of the Fraunhofer lines on the solar flux to be seen.

It is a general conclusion of solar research that the flux in this part of the ultraviolet does not vary with the solar cycle. Therefore solar activity does not need to be considered. For shorter wavelengths, through the far and extreme UV, the flux does vary with solar activity and this conclusion does not apply.

While the LOWTRAN 7 code handles solar scatter very well, as we demonstrate in this paper, it does require further development to handle situations where there is airglow or fluorescence. These situations occur at night and for limb observations that do not include the scattering regions in the line-of-sight. It is planned to build on the present model to add airglow and fluorescence contributions in the future. In addition, the extension of models with the capability of LOWTRAN to at least 100 nm is needed.

3. SATELLITE RADIANCE MEASUREMENTS

The model measurements can be compared with the results of the experiment VUV Backgrounds on the S3-4 satellite. These measurements, which were published in 1980[4], used dual Ebert-Fastie one-quarter meter spectrometers to obtain the atmospheric radiance in the 110-290 nm region. The satellite was in a polar orbit at about 200 km altitude and all measurements were in the nadir (earth-center) direction.

The measurements were acquired in the April-September 1978 time period. Spectral bandwidths of 1, 5, and 25 Angstroms were used. The dual spectrometer used photomultiplier tubes for detectors. A tube with a cesium iodide photocathode was used for the 'VUV' range from about 110 to 180 nm. The data used for this comparison was obtained with the 'UV' range, from about 160 to 290 nm. The photomultiplier had a cesium telluride photocathode. The spectrum over the combined range of the dual spectrometer was scanned in about 22 seconds, during which time the satellite had moved about 170 km. For scattering and airglow in the mid-latitude and high sun conditions, no geophysical spatial structure would be expected.

The experiment included a sensitive photometer with a filter wheel. With this instrument, data at four wavelength bands centered at 1216, 1340, 1550, and 1750 Angstroms were obtained.

The sensors were calibrated on the ground against standard detectors from the NBS (now called NIST). The spectrometers appeared to hold their calibration over the six months of the flight. However, some degradation was noticed for the photometer. The satellite was in a sun-synchronous orbit with the day crossing of the equator at about 1030 hours.

4. COMPARISON OF CODE AND MEASUREMENTS

Figures 1, 2, 3, and 4 compare results of the model with the measurements. The solar zenith angle is 24, 70, 90, and 94 degrees for the figures. The solid curves are the model and the dashed lines are the measurements.

Note how the measurements and the model are in close agreement for both the structure in the curve and for the absolute value. As the solar zenith angle increases, the intensity of the radiance drops from thousands to tens of Rayleighs per Angstrom.

For the SZA of 94 degrees, the breakdown of the current model can be seen. There are a series of peaks in the measurements above the mean background level. In this twilight situation, the solar scatter is becoming very weak. At the same time, the fluorescence of atmospheric nitric oxide excited by solar radiation comes to dominate the emission. The large peaks are all due to the NO gamma bands, which are well known both in the laboratory and from space observations.

At night, there is weak NO and molecular oxygen emission from chemically produced airglow. These excitation sources are not in the current code. Both these sources and fluorescence must be added to have a representative mid-latitude model.

5. CONCLUSIONS

The excellent agreement of the solar scatter code and measurements also prompts us to use the code to extend the UV radiance to the 290-400 nm region for which we do not have detailed measurements. This extension is shown in Fig. 5. With the use of these curves, applications of the UV to remote sensing can be evaluated.

The availability of the LOWTRAN 7 model has lead to a revision of the previously published ultraviolet radiance curve for midlatitude, nadir-viewing, overhead sun conditions[3]. The curve originally put in the Handbook did not include the structure observed in the 200-290 nm region. This structure has now been added and the current version of the curve is shown in Fig. 6.

6. ACKNOWLEDGEMENTS

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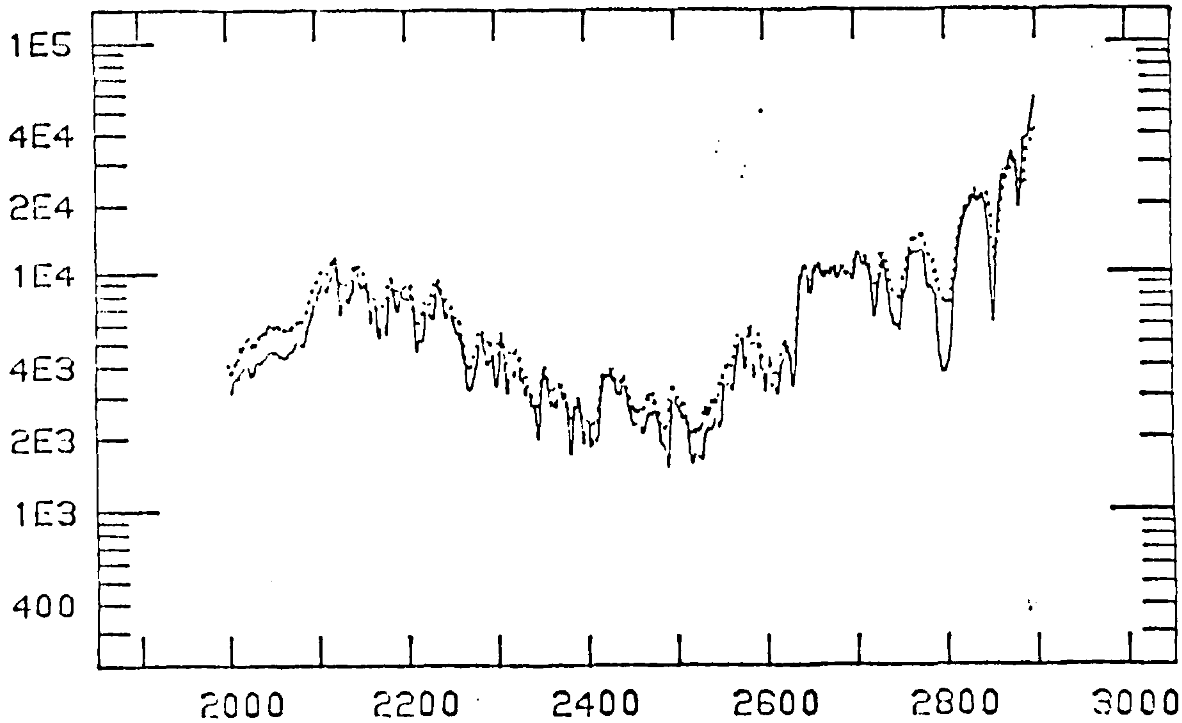

Figure 1. Comparison of LOWTRAN 7 model (solid curve) and S3-4 satellite data (dashed curve) for UV radiance. Solar zenith angle (SZA) is 24 degrees. Horizontal scale is wavelength in Angstroms. Vertical scale is radiance in Rayleigh/Angstrom. Applies also to Figs. 2, 3, and 4.

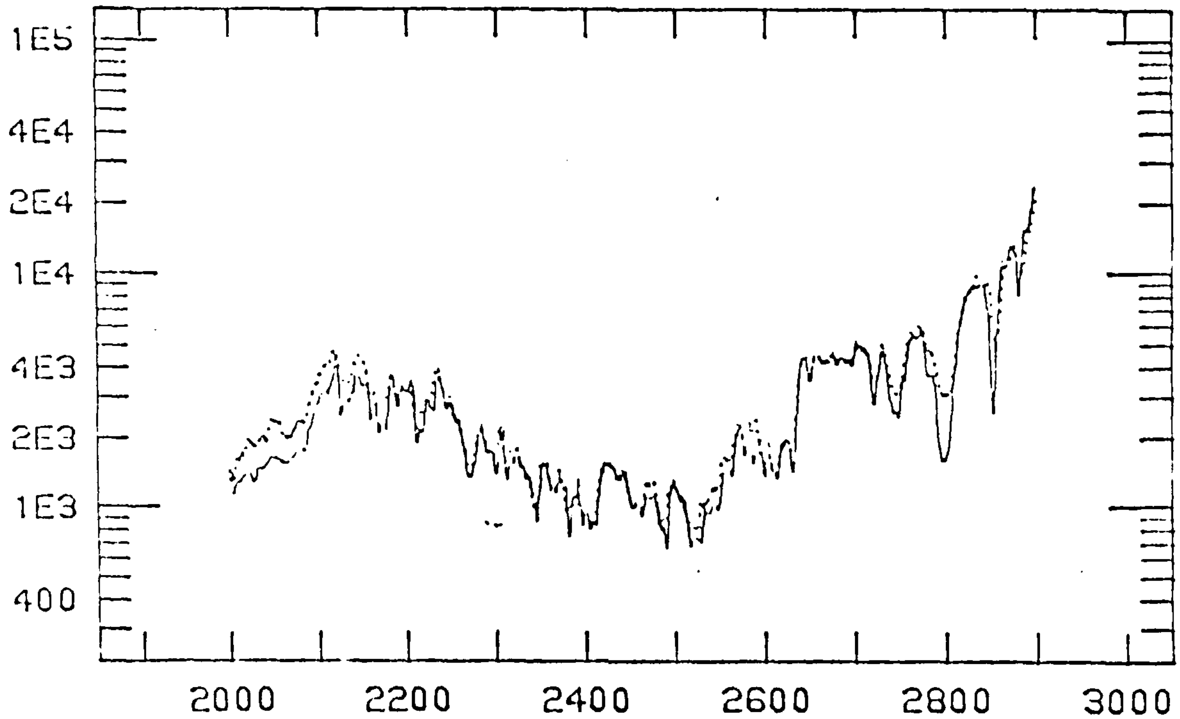

Figure 2. Same as Fig. 1, except SZA = 70 degrees.

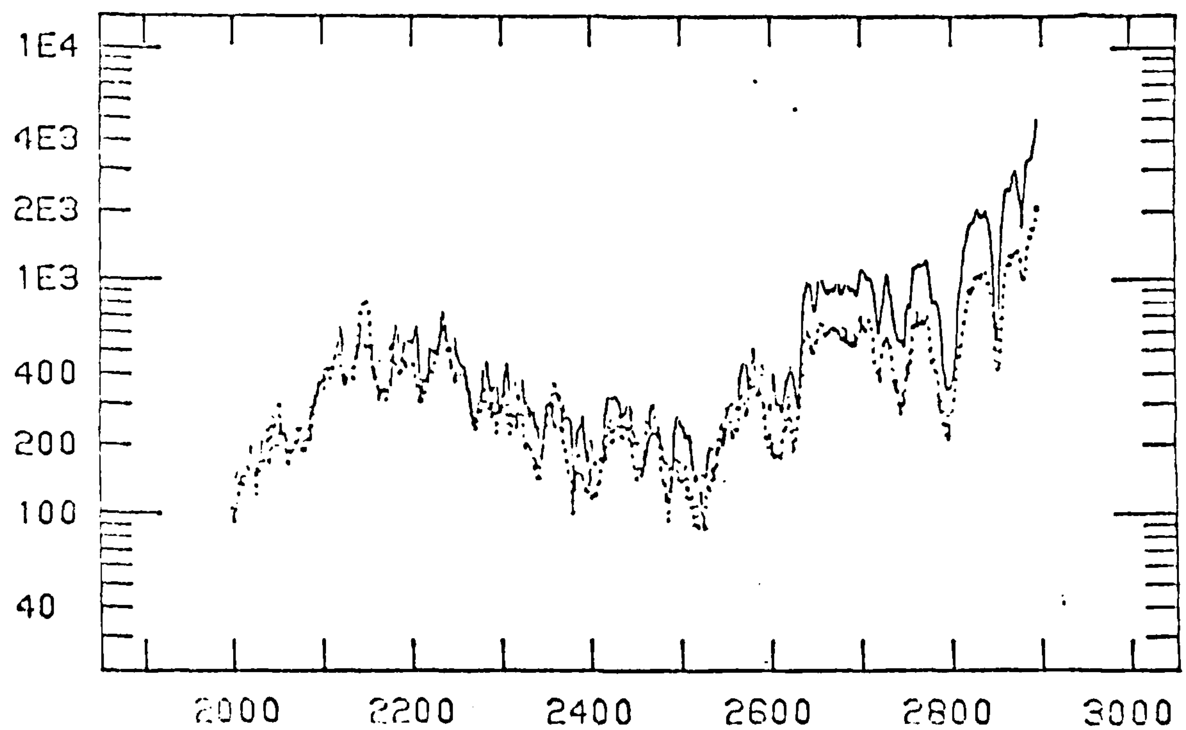

Figure 3. Same as Fig. 1 except SZA = 90 degrees.

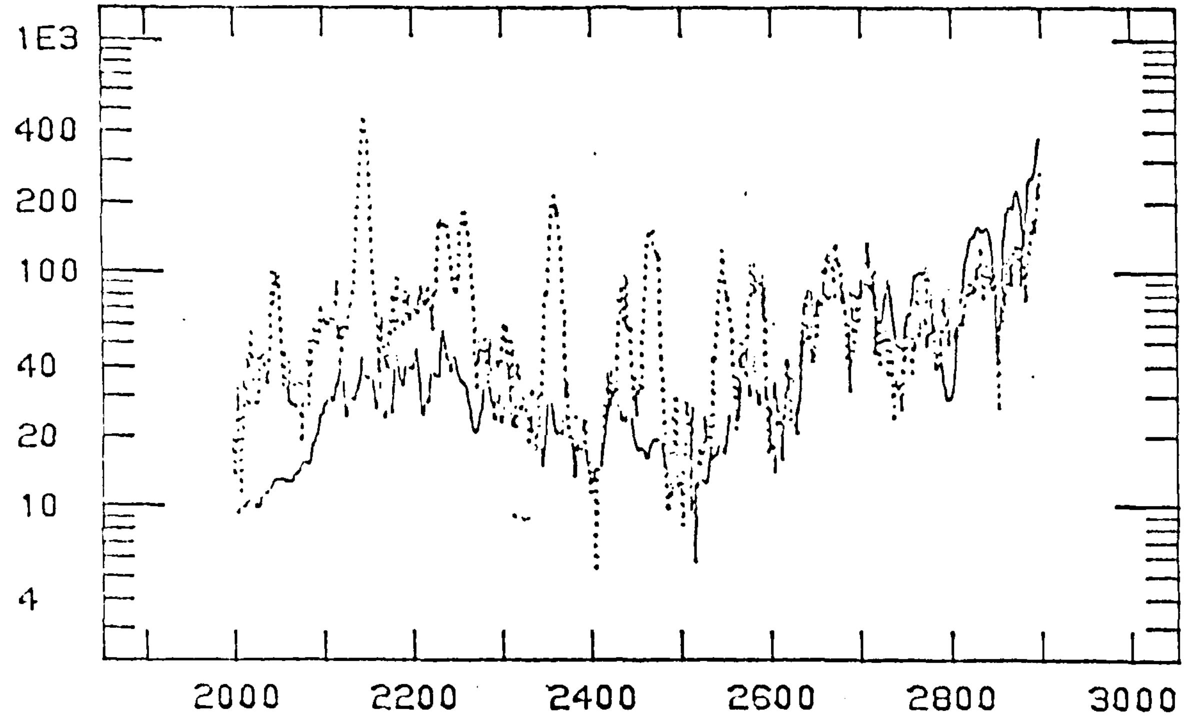

Figure 4. Same as Fig. 1 except SZA = 94 degrees.

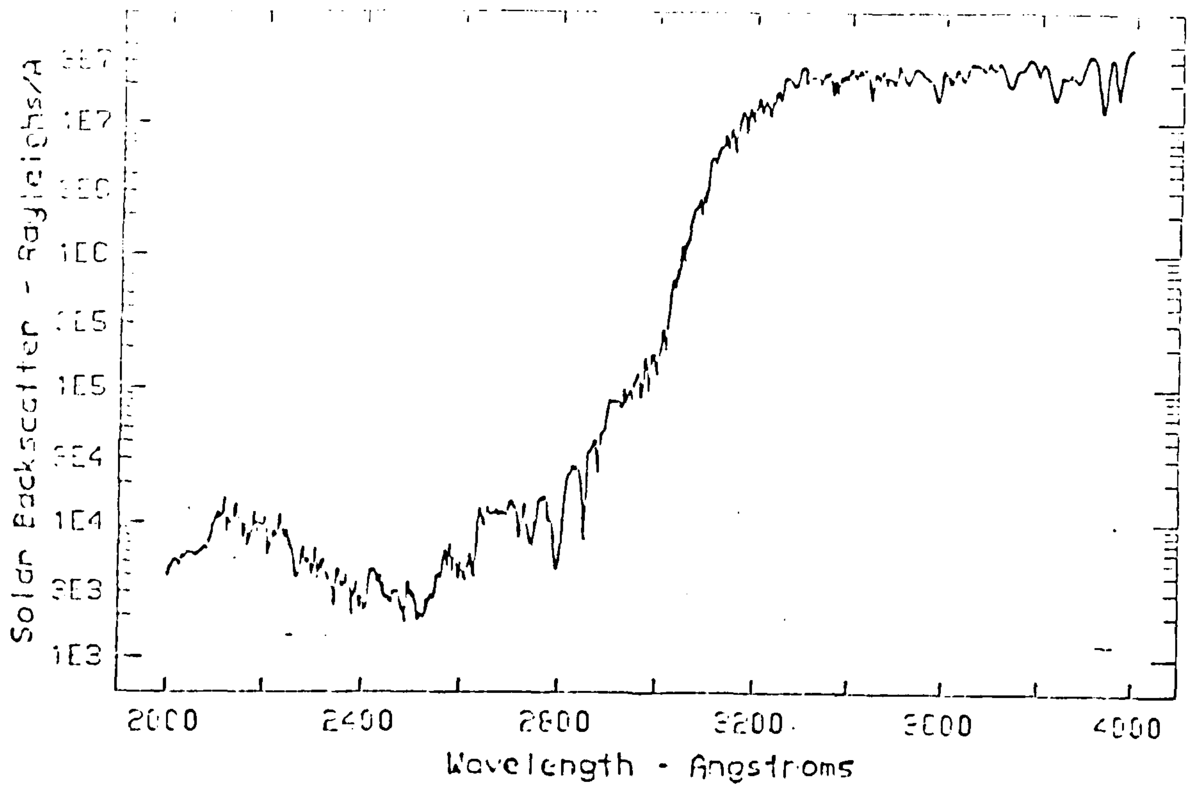

Figure 5. LOWTRAN 7 radiance values. Nadir view, SZA=0 deg., 5 Angstrom resol. Albedo = 0.2, multiple scattering.

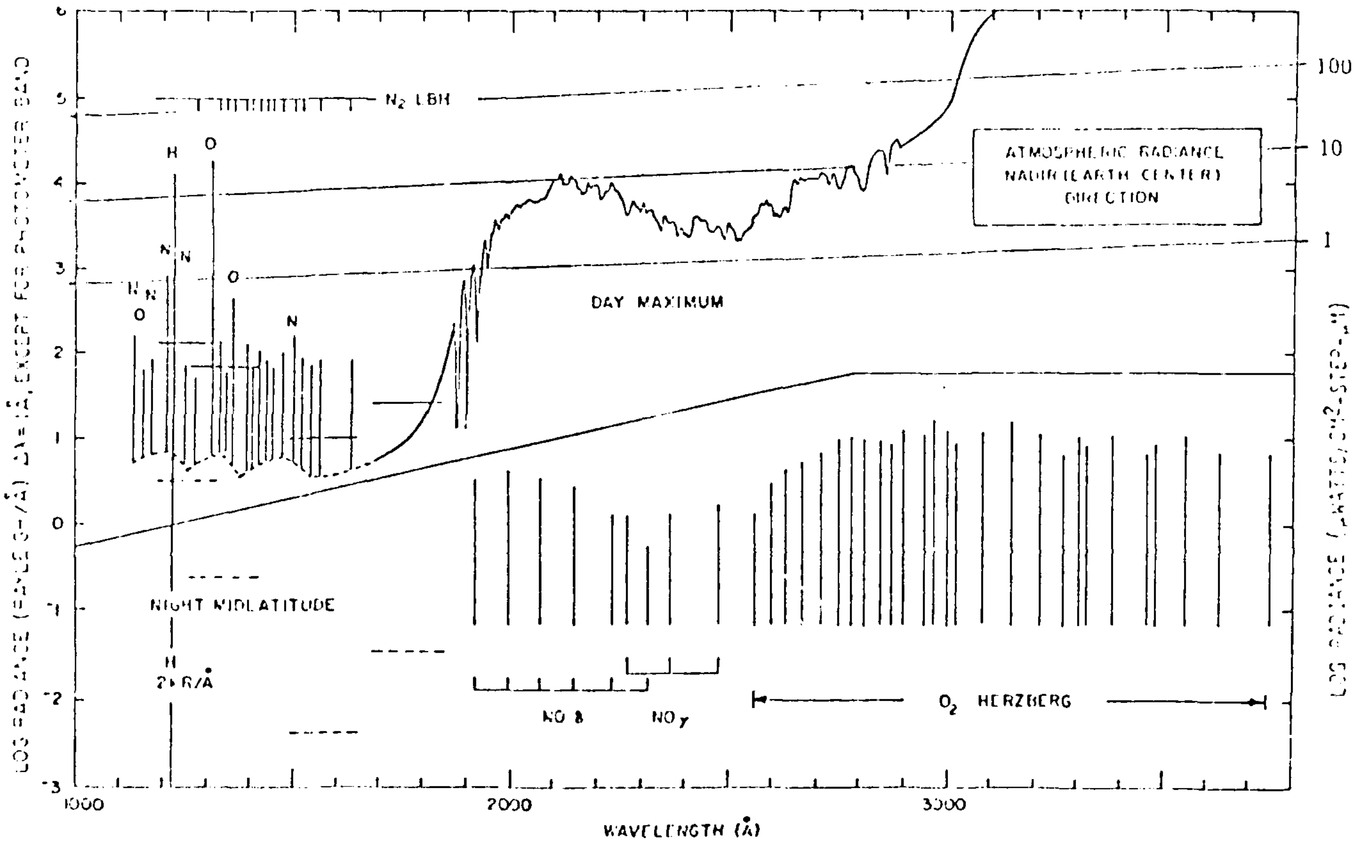

Figure 6. Day and night earth radiance values. Nadir view, SZA = 0 degrees, Midlatitudes. Revision of the Handbook of Geophysics curve[3].

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